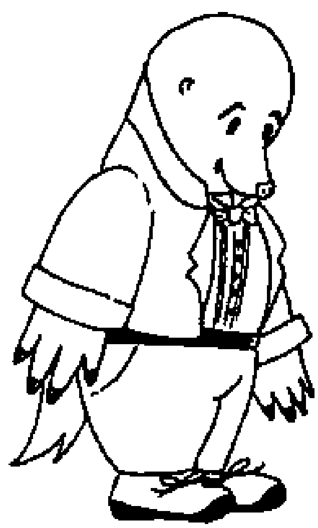
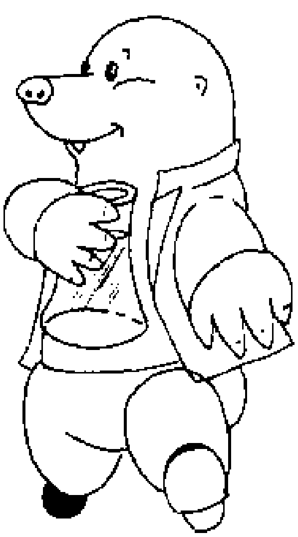
Chemistry I
The Mole
Study Guide





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Chemistry I: The Mole

The **mole is the standard unit of measurement in chemistry** for communicating how much of a substance is present.

Here is how the International Union of Pure and Applied Chemistry (IUPAC) defines "mole:"

> The mole is the amount of substance of a system, which contains as many elementary entities as there are atoms in 0.012 kilogram of carbon-12. When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles.

This is the fundamental definition of what one mole is. One mole contains as many entities as there are in 12 grams of carbon-12 (or 0.012 kilogram).

In one mole, there are 6.022×10^{23} atoms. Here's another way: there are 6.022×10^{23} atoms of carbon in 12 grams of carbon-12.

Let me put it this way: one mole of ANYTHING contains 6.022×10^{23} entities.

The word "entities" is simply a generic word. For example, if we were discussing atoms, then we would use "atoms" and if molecules were the subject of discussion, the word entities would be replaced in actual use by "molecules."

For example:

- One mole of Na^{+1} contains 6.022×10^{23} ions
- One mole of H_2O contains 6.022×10^{23} molecules
- One mole of nails contains 6.022×10^{23} nails
- One mole of Fe contains 6.022×10^{23} atoms
- One mole of chocolate chip cookies contains 6.022×10^{23} chocolate chip cookies
- One mole of electrons contains 6.022×10^{23} electrons

The symbol for mole is "mol "

Avogadro's Number has been very carefully measured in a number of ways over many decades. 6.022×10^{23} is so important in chemistry that it has a name. It is called Avogadro's Number and has the symbol N. It is so named in honor of Amedeo Avogadro, an Italian chemist, who, in 1811, made a critical contribution (recognized only in 1860 after his death), which helped greatly with the measurement of atomic weights.

Avogadro's Number has a unit associated with it. It is mol^{-1}, as in 6.022×10^{23} mol^{-1}. The superscripted minus one means the unit mol is in the denominator. There is an understood numerator of one, as in 1/mol.

We write it this way: $$\frac{6.02 \text{ X } 10^{23} \text{ (whatevers)}}{\text{mol}}$$

Getting back to Avogadro's Number role in chemistry; note that counting atoms or molecules is very difficult since they are so small. **However, we can "count" atoms or molecules by weighing large amounts of them on a balance.**

When we weigh one mole of a substance on a balance, this is called a "**molar mass**" and has the units **g/mol (grams per mole).** This idea is very critical because it is used all the time. Therefore, a molar mass is the mass in grams of 6.022×10^{23} entities.

- A molar mass is the weight in grams of one mole.
  - The atomic weight is the mass of one mole of an element.
  - The formula weight/molecular weight is the mass of one mole of that substance.
- One mole contains 6.022×10^{23} entities.
- One mole of any gas will occupy 22.4 L at standard temperature and pressure, which happens to be 273 K and 760 mm of Hg.

To review:

Molar mass is calculated by adding all of the atomic weights of all of the atoms of an element in a compound:

Calculate the molar mass of $Al(NO_3)_3$

(1 x 26.98) + (3 x 14.007) + (9 x 16.00) = 213.00 g/mol

213.00 grams is the mass of one mole of aluminum nitrate.

213.00 grams of aluminum nitrate contains 6.022×10^{23} entities of $Al(NO_3)_3$

Using factor-label method and **on a separate piece of paper**, solve the following problems.

Calculate the mass in grams of each of the following:

1) 5.0 moles of carbon
2) 8.00 moles of aluminum
3) 10.5 moles of elemental oxygen (O_2)
4) 4.0 moles of mercury
5) 7.00 moles of elemental iodine (I_2)
6) 200 moles of sodium

Calculate the number of moles of atoms in the following:

7) 800 g of calcium
8) 280 g of krypton
9) 560 g of zinc
10) 66 g of manganese
11) 93 g of phosphorous
12) 72 g of silicon

Calculate the number of atoms in:

13) 3.2 moles of lithium
14) 5.40 moles of copper
15) 1.0 moles of boron
16) 4.1 moles of sodium
17) 9.7 moles of gold
18) 4.78 moles of cesium

Calculate the number of mole in the following:

19) 3.01×10^{23} atoms of Cd
20) 5.78×10^{3} atoms of Ga
21) 56 atoms of K
22) 4.99×10^{24} atoms of Ar
23) 9.03×10^{16} atoms of As

Calculate the mass in grams of the following:

24) 5.4 moles of ZnO

25) 12.0 moles of PbS

26) 7.50 moles of sugar($C_{12}H_{22}O_{11}$)

27) 200 moles of Al_2O_3

28) 40 moles of Na_2CO_3

29) 8.7 moles of $Ca(NO_3)_2$

Calculate the number of moles in each of the following:

30) 400 grams of NaOH

31) 599 grams of $Pb_3(PO_4)_2$

32) 5 grams of CoS

33) 119.78 g of Ag_2O

34) 312 g of H_2O

35) .O.38 grams MgO

Calculate the number of molecules in:

36) 3.5 moles of C_2H_6

37) 5.25 moles of sugar

38) 22 grams of CO_2

39) 2.55 kg of CaS

Calculate the following:

40) mass of 192 moles of $MgSO_4$

41) number of atoms in 44 moles of B

42) grams of Na in 13.3 moles

43)# of molecules in 55 grams of sugar ($C_{12}H_{22}O_{11}$)

44) moles in 335 grams of $NaNO_3$

45) # of moles in 3.97 X 10^{24} M&M's

The following problems deal with the amount of gas in a mole. However, specific conditions must apply to the gas substance for these answers to be correct. We will learn in the Gas Laws Unit that the volume of a gas will change with temperature and pressure. For these problems we will assume that the gasses are at standard temperature and pressure (STP). We will learn more about this later.

Note: There are 22.4 L of as gas in one mole at STP.

How many moles of gas are in the following:

46) 33.3 L H_2

47) 500 L C_3H_8

48) 44.8 L N_2

49) 99.9 L Cl_2

50) 100 L CH_4

How many liters of gas (@ STP) are in the following:

51) 234 mol Ar

52) 2.89 mol N_2

53) 1 mol Kr

54) 0.02 mol H_2

How many molecules of gas are in the following:

55) 4 mol F_2

56) 55 L CH_4

57) 35 L CO_2

Calculate the following:

58) mass of CO_2 in 34 L

59) volume in mL occupied by 10 g CO_2

60) mass in mg of 100 mL of SO_3

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